GEARTRAIN COUPLING FOR A TURBOFAN ENGINE

BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention relates to turbomachinery, and more particularly to geared turbofan engines.

(2) Description of the Related Art

In high bypass turbofan engines it is advantageous that the turbine drive the fan through a reduction gearing system. This permits the turbine to operate at the relatively high speeds at which it is efficient while the much larger diameter fan operates at the relatively lower speeds at which it is efficient. One possible gearing system is a planetary system. In exemplary implementation, the turbine shaft directly drives a sun gear. A number of planet gears are enmeshed between the sun gear and a ring gear that is non-rotating relative to an engine nacelle or other environmental structure in which the turbofan is mounted. The fan is directly driven by a cage holding the planet gears. Bearings are typically provided: (a) for supporting the turbine shaft and sun gear relative to the environment; and (b) for rotatably supporting the planetary gears relative to the cage. Whereas the former are often rolling-element bearings, the latter are advantageously journal bearings. Journal bearings may offer an advantageous balance of compactness and load-carrying ability.

To operate under the relatively high power transmission conditions of the turbofan engine, the journal bearings will typically require lubrication. Oil is advantageously used as a lubricant. Depending on the engine and application, various operating conditions may cause short periods in which the bearings operate under mixed or boundary lubrication conditions, potentially resulting in bearing wear. Additionally, failures of lubrication systems must be contemplated. In an aircraft application, it is particularly desirable that the bearings not seize for a substantial time after a lubrication failure period. Many forms of engine damage may cause such failure. In an aircraft application if rotation of the damaged engine were stopped, the stopped engine would constitute an extreme source of aerodynamic drag. Accordingly, the damaged engine is advantageously allowed to rotate, driven by the air flow resulting from the forward velocity of the aircraft in a process called "windmilling". The engine so rotates at a rotational speed, typically substantially less than that of a powered engine. A windmilling engine has significantly less aerodynamic drag than does a completely stopped engine. Under the Extended Range Twin-Engine Operations (ETOPS) rating system, certain aircraft may be required to operate with a windmilling engine for a period of up to 180 minutes.

In order to prevent seizure and improve life, it is advantageous that the journal outer surface and/or sleeve inner surface be provided with a lubricious coating.

BRIEF SUMMARY OF THE INVENTION

I have determined that molybdenum disulfide (MoS_2) can be a particularly effective journal coating for turbine gearing systems. Particularly advantageous coatings include sputter-deposited MoS_2 and cathodic arc-deposited fullerene-like MoS_2.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic longitudinal view of a geared turbofan engine.

FIG. **2** is a longitudinal semi-schematic sectional view of a transmission of the engine of FIG. **1**.

FIG. **3** is a transverse schematic sectional view of the transmission of FIG. **2**.

FIG. **4** is a longitudinal semi-schematic sectional view of a journal of the transmission of FIG. **2**.

Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

FIG. **1** shows a geared turbofan engine **20** having a main housing **22** containing a rotor shaft assembly **24**. An exemplary engine is a high-bypass turbofan. In such an engine, the normal cruise condition ratio of air mass flowing outside the core (e.g., the compressor sections and combustor) to air mass passing through the core (the bypass ratio) is typically in excess of 4.0 and, more narrowly, typically between 4.0 and 8.0. Via the shaft **24**, a turbine section **26** drives high and low pressure compressor sections **28** and **30**. The engine extends along a longitudinal axis **500** from a fore end to an aft end. Adjacent the fore end, a shroud **40** encircles a fan **42** and is supported by vanes **44**. The rotor shaft assembly **24** drives the fan **42** through a reduction transmission **46**. An exemplary reduction transmission is a planetary gear system. FIG. **2** shows further details of the transmission **46**. A flexible input shaft **50** at a forward end of the rotor shaft assembly **24** is secured to a sun gear **52**. The externally-toothed sun gear is encircled by an internally-toothed ring gear **54** which is substantially irrotatably mounted relative to the housing **22**. A number of externally-toothed planet gears **56** are positioned between and enmeshed with the planet gear and ring gear. A cage or planet carrier assembly **60** carries the planet gears via associated journals **62**. The journals have circumferential surface portions **64** closely accommodated within internal bore surfaces **66** of the associated planet gears. The speed reduction ratio is determined by the ratio of diameters of the ring gear to the sun gear. This ratio will substantially determine the maximum number of planet gears in a given ring. The actual number of planet gears will be determined by stability and stress/load sharing considerations. An exemplary reduction is between 2.2:1 and 3.5:1. An exemplary number of planet gears is between 3 and 7. FIG. **3** schematically shows the equally-spaced positioning of five planet gears **56** about the sun gear **52**.

FIG. **4** shows additional structural details of an exemplary journal **62**. The exemplary journal comprises the unitary combination of a central section **70** and shaft sections **72** and **74** extending from ends of the central section. The surface portion **64** is formed along the central section **70**. Bores **80** and **82** may extend inward from the outboard ends of the shaft sections **72** and **74**. The exemplary bore **82** forms the trunk of an oil conduit from which radial branch bores **84** extend to the surface **64** for maintaining the lubricant film between the journal and planet gear. A filter **88** may be located in the bore **82** for providing a final filtration stage for the oil. Diverse journal structures are known and may be developed, and the principles of the present invention may be applied to various such journals. For example, journals coated according to principles of the present invention may be used as drop-in replacements for existing journals, in which cases they could be otherwise structurally similar to those existing journals. Among various possible modifications to the schematic journal structure shown is the presence of undercuts or grooves extending inward from the end